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1. Your reference — P32366-/LBA/RDE/GMU

2. Patent application number *(The Patent Office will fill in this part)* — 0306075.3 — 17 MAR 2003

3. Full name, address and postcode of the or of each applicant *(underline all surnames)* —
Renewable Devices Ltd
SAC Bush Estate
Edinburgh
EH26 0HP
United Kingdom

Patents ADP number *(if you know it)* — 8589483001

If the applicant is a corporate body, give the country/state of its incorporation — United Kingdom

4. Title of the invention — Wind Turbine

5. Name of your agent *(if you have one)* — Murgitroyd & Company

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)* —
Scotland House
165-169 Scotland Street
Glasgow
G5 8PL

Patents ADP number *(if you know it)* — 1198015

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Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

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Signature Murgitroyd & Company Date 17 March 2003

12. Name and daytime telephone number of person to contact in the United Kingdom GRAHAM MURNANE 0141 307 8400

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Wind turbine

The invention relates to wind turbines, and more particularly to a wind turbine for mounting on a roof and for use with a domestic heating system.

Governments are committed to reduce CO_2 emissions over the next few years. Along with energy efficiency measures there has been an increased emphasis on renewable sources of energy. Analysis of energy demand shows that 6% of the UK's annual energy demand is from domestic water heating and 12% from domestic space heating. Use of wind turbine technology could provide substantial economic benefits to over 33% of UK households and could reduce the UK's CO_2 emissions by as much as 2%. Similar benefits are possible in other countries.

Existing micro wind turbines used to generate domestic electricity require expensive intermediate battery systems to compensate for the unregulated and inconsistent supply of electricity produced.

Existing turbines of a size suitable for mounting on a roof to provide domestic power are designed for smooth airflow only and will oscillate violently with the compressed and turbulent airflow found over, and around, buildings creating noise and inefficient generation.

It is an object of the present invention to overcome one or more of the aforementioned problems.

According to a first aspect of the invention there is provided a rotor for a wind turbine comprising a plurality of radial blades and a ring-shaped aerofoil diffuser connecting the outer tips of the blades.

Preferably the aerofoil diffuser extends downstream from the outer tips of the blades. The outer tips of the blades may be connected to the diffuser at the leading edge of the diffuser. Preferably the aerofoil diffuser tapers radially outwards from the outer tips of the blades to form a substantially frusto-conical diffuser.

Preferably the blades are inclined at an angle relative to a transverse rotor plane perpendicular to the rotational axis of the rotor. The angle of inclination may vary along the length of the blade.

Preferably the angle of inclination of each blade is greater at an intermediate portion of the blade than at the outer tip of the blade. Preferably the blade

is substantially parallel to the transverse rotor plane at the outer tip of the blade.

According to a second aspect of the invention there is provided a wind turbine comprising a rotor according to the first aspect. Preferably the wind turbine further comprises mounting means adapted to allow rotation of the turbine and rotor about a directional axis perpendicular to the rotational axis. This allows the turbine to be oriented in the optimum direction depending on wind conditions.

Preferably the wind turbine further comprises a furling means adapted to rotate the rotor about the directional axis so that the rotational axis is not parallel to the direction of airflow when the airflow speed is greater than a predetermined airflow speed. Preferably the aerofoil diffuser is adapted to divert radial airflow from the outer tips of the blades to circumferential airflow during furling when the rotational axis is not parallel to the direction of airflow.

Preferably the furling means comprises a non-linear furling means adapted to provide no furling over a first lower range of airflow speed and a varying degree of furling over a second higher range of airflow speed. Preferably the furling means comprises at least two tail fins extending downstream of the diffuser. Preferably the furling means comprises two tail fins provided diametrically opposite each other, but more tail fins may be

provided if required, providing the positions of the tail fins are balanced.

Preferably one of the tail fins is a moveable tail fin hingedly mounted for rotation about a tangential hinge line. The moveable tail fin may be mounted on mounting boom and the hinge line may be provided at the connection point of the mounting boom and the nacelle, so that the mounting boom also rotates, or at the connection between the mounting boom and the moveable tail fin so that only the moveable tail fin rotates.

Preferably the moveable tail fin is rotationally biased by biasing means to an at-rest position in which the leading edge of the moveable tail fin is closer to the axis of rotation than the trailing edge of the moveable tail fin, such that the moveable tail fin is angled at an at-rest attack angle to the axis of rotation. The biasing means may be non-linear. Preferably the biasing means is adapted to hold the moveable tail fin in the at-rest position until the airflow speed reaches a predetermined speed. Preferably, as the airflow speed increases beyond the predetermined speed the upstream fin rotates and the attack angle decreases. This results in unbalanced aerodynamic loading on the wind turbine, so that the wind turbine rotates about its mounting axis to a furled position.

According to a third aspect of the present invention there is provided a wind turbine heating system comprising:

a wind turbine driven generator,

a first liquid storage vessel,

one or more electrical heating elements adapted to heat liquid in said first vessel, and

control means adapted to control the supply of electricity generated by said generator to said one or more electrical heating elements.

Preferably the system comprises a wind turbine according to a second aspect of the invention.

Preferably the first liquid storage vessel is a domestic hot water tank and the liquid is water.

Preferably the system comprises a plurality of electrical heating elements, and the control means is adapted to supply electrical power to a proportion of the electrical heating elements, the proportion being dependent upon the instantaneous electrical power generated by the generator.

The system may comprise a second liquid storage vessel and one or more auxiliary electrical heating elements adapted to heat liquid in said second vessel. The control means may be adapted to supply electrical power to said one or more auxiliary electrical heating elements when the temperature of the liquid in the first vessel reaches a predetermined temperature. In one embodiment the

second liquid storage vessel is a domestic cold water tank and the liquid is water. In another embodiment the second liquid storage vessel is a radiator.

Preferably the heating element in the first liquid vessel is enclosed by means of a tube. This tube is open on the underside thereof in order to allow water to flow from beneath the tube towards the heating element. The tube will enclose and extend over in essence the entire length of the heating element. The water near the heating element will be heated and will flow upwards due to natural convection. The presence of the tube will direct the heated water towards a zone of the heated water. The presence of the tube will enable the formation of different and seperate heat zones within the first liquid storage vessel.

Preferably, the wind turbine heating system according to the present invention is provided with a control system in order to control the level of power taken from the wind turbine. For efficiency reasons the maximum power take-off from the wind turbine is approximately 60%, as given by the Betz limit. According to the present invention the control system of the wind turbine will measure the energy yield of the wind turbine in real time. The control system is adapted to increase or decrease the power take-off from the wind turbine by a small amount. After a certain time period, the control system will measure the energy yield of the wind

turbine again. The variation in the yield is determined and the amount of power taken from the wind turbine is again adjusted, depending on the measured value for the yield. When the extra load on the wind turbine causes the yield of the wind turbine to increase the control system will increase the load on the wind turbine further by a small amount. Thereafter the yield of the wind turbine is again measured in order to determine the effect of the further increase of the load on the yield of the turbine. If the increase of the load will result in a decrease of the yield, the process is reversed.

According to a fourth aspect of the invention there is provided a wind turbine according to the second aspect comprising means for reducing the operating vibrations caused by harmonic resonance within the turbine, tower and mounting structure.

Preferably the wind turbine is provided with a nacelle damping system. The nacelle damping system according to the invention will help to isolate the vibrations in the generator and turbine from the tower.

Preferably the wind turbine is provided with mounting brackets for mounting the turbine on a surface, the brackets having a sandwich construction of visco-elastic materials and structural materials.

The mounting means can be of any cross-sectional shape, but is typically tubular. Preferably, the

tower contains one or more cores of flexible material, such as rubber, with sections with a reduced diameter, which are not in contact with the tower's inner radial surface. These reduced diameter sections alternate with normal sized sections, which are in contact with the tower's inner surface.

This serves to absorb vibrations in the tower through the energy dissipated in the flexible core before they reach the mounting brackets. The rubber core thereby acts to force the system's resonant frequency above the turbine driving frequency. By altering the cross-sectional shape and length of each of the reduced diameter sections, the system can be "tuned" to remove a range of vibration frequencies from the mounting structure.

The sandwich mounting bracket compliments the mounting means core design and suppresses vibrations that come from the nacelle. The nacelle itself supports the generator through bushes designed to eliminate the remaining frequencies. These three systems act as a high/low pass filter where the only frequencies that are not attenuated are those out-with the operating range of the turbine.

An embodiment of the present invention will now be described with reference to drawings wherein:

Fig 1 shows a schematic view of the wind turbine according to the present invention;

Fig 2 shows a top view of the rotor and the furling device of the wind turbine according to Fig 1;

Fig 3 shows in detail an embodiment of one boom of the furling device according to the present invention;

Fig 4 shows the connection of the boom according to Fig 3 through the nacelle;

Fig 5 shows the connection of the tip of the boom according to Fig 3 to the tail fin;

Fig 6 shows a schematic overview of a heating device for heating water which is adapted to be coupled to a wind turbine according to the present invention;

Fig 7 shows diagramatically the working of the control system of the heating device according to Fig 6;

Figs 8 and 9 show a further embodiment of a heating device for heating water, which is adapted to be connected to the wind turbine according to the present invention; and

Fig 10 shows a cross-sectional view of the mounting means for the wind turbine according to the present invention, wherein the interior is provided with a vibration damping core.

Figs 11 and 12 show a cross-sectional view of the mounting means according to Fig 10 as alternative embodiments for the vibration damping core.

In Fig 1 a possible embodiment of the wind turbine according to the present invention is shown. The wind turbine comprises a rotor 20 having a core 25 and radial blades 30 extending from the core 25 towards the outer tip 31 of the blades 30. The rotor comprises a radial aerofoil 21, attached to and encircling the rotor blades 30. The rotor 20, by means of the core 25, is rotationally fixed to a nacelle 41. The rotor 20 is able to rotate about the rotational axis 26. The nacelle 41 is rotationally mounted on top of mounting means 40. The mounting means 40 allow the wind turbine 10 to be fixed on a support (not shown). The nacelle 41 moreover is provided with a furling mechanism 50. The furling mechanism 50 comprises a first boom 51 and a second boom 52. The booms 51,52 and their respective ends thereof are provided with tail fins 53,54.

The furling mechanism 50 has two functions. The first function is to keep the rotational axis 26 of the rotor 20 essentially parallel to the momentaneous direction of the airflow. In Fig 1 the airflow is schematically indicated by means of arrows 15. The second function of the furling device 50 is to rotate the rotor 20 out of the wind when the wind velocity exceeds the output power requirements of the wind turbine or endangers the

system's integrity, in order to protect the wind turbine 10 against unacceptable high loads.

The construction and the working of the furling mechanism will be clarified below, with reference to Figs 2, 3, 4 and 5.

As shown in Fig 1, the radial aerofoil 21 is attached to and encircles the turbine blades 30. The radial aerofoil 21 will create a slight venturi effect near the blade tips where the resulting increase in air velocity has the largest effect. This increases the overall efficiency of the turbine 10, which compensates for the slight increase in weight and drag caused by the addition of the aerofoil 21. The aerofoil will also create a more laminar flow along the rotor blades. This is important since the airflow on a roof typically is turbulent. A further advantage is the fact that the presence of the radial aerofoil 21 will increase the mechanical strength of the rotor 20, allowing more efficient aerofoil section to each blade 30.

In Fig 1 it can be seen that the design of the blade 30 is such that the outer tips 31 of the blade 30 are in essence perpendicular to the rotational axis 26.

The outer tips 31 of the blade are connected near the leading edge 22 of the aerofoil 21. The number of blades 30 may be varied.

In Fig 2 a top view is shown of the rotor 20 and the furling device 50 of the wind turbine 10 according to Fig 1. The furling device 50 comprises booms 51,52 each provided with a tail fin 53,54 at the end thereof. The airflow 15 will exert a certain pressure on the tail fins 53,54. The tail fins will balance and stabilise the position of the rotor 20 with respect to the direction of the airflow 15. When the direction of the airflow 15 changes the resulting pressure on the tail fins 53,54 will also change. The resulting force will cause the rotor 20 to rotate in order to maintain the direction of the airflow 15 in essence in line with the rotational axis 26 of the rotor 20. During normal furling the presence of the aerofoil 21 will reduce vibrations caused by imbalanced blade tip vortex shedding. This is achieved in that the aerofoil will act to divert the airflow from the blade tips during furling.

The furling device 50 according to the present invention not only maintains an optimal angle between the rotor 20 and the airflow 15, but in addition acts to protect the turbine 20 during excessively high wind loadings. The furling device 50 is designed to rotate the turbine 20 out of the airflow when the wind velocity exceeds the output power requirements of the turbine or when the wind loading compromises the integrity of the rotor 20. As shown in Fig 2, the tail fins 53,54 form a wedge pointing into, out of substantially parallel to the wind. Excessive wind loadings will make the tail

fins 53,54 move and/or rotate with respect to the nacelle 41. Preferably one of the fins has no travel or limited travel, causing the rotor 20 to furl as the second fin continues to rotate under high airflow velocities. It means that the furling mechanism 50 according to the present invention under moderate wind velocity will keep the rotor 20 in a stable condition and at a preferred angle with respect to the airflow 15. Only after exceeding a predetermined wind velocity, the same furling device 50 will cause the rotor 20 to rotate out of the wind in order to protect the integrity thereof.

The construction of the furling device 50 according to the present invention causes the furling device to act non-linearly in relation to the wind velocity. The furling device 50 limits the turbine's susceptibility to gusts and turbulence. Light gusts will not be able to move the rotor out of the wind. The safety function of the furling device 50 will only operate in high wind situations in order to protect the turbine and a respective generator.

As shown in Fig 2 the booms 51 and 52 extend from the nacelle to the tail fins, in the downwind direction of the rotor 20. The respective tail fins 53 and 54 are positioned essentially in line with the exterior dimensions of the rotor 20. The construction of the furling device 50 according to the present invention enables a compact construction and does not necessitate free space behind the

nacelle 41. That means that the design of this furling system allows the overall length of the turbine to be considerably reduced when compared to existing wind turbines.

In Figs 3 and 4 the first embodiment of the boom 51 and respective tail fin 53 is shown. The arrows indicate the movement of the boom 51 with respect to the nacelle 41. The angle between the rotation axis 26 of the rotor (not shown) and the tail fin 53 is changed by use of a hinge 60 located at the base of the boom 51. As shown in Fig 4, the boom 51 is held at a fixed angle to axis 26 by a coil spring 61. When the wind loading on the fin 53 is sufficiently large, the boom 51 and the fin 53 rotate against the retaining force of the coil spring 61, causing an out of balance aerodynamic loading on the rotor 20. This out of balance force will cause the nacelle to rotate about its mounting axis 42 (see Fig 1). It should be noted that the coil spring 61 as shown in Fig 4 is simply for explanatory purposes and any type of spring could be used in the hinge 60.

In Fig 5 an alternative embodiment is shown wherein the rotation of the furling fin takes place about a hinge 70 located at the outer tip of the boom. As shown in Fig 5 clockwise rotation of the fin 53 at the hinge 70 is limited by an end stop 71. The anti-clockwise rotation of the fin 53 is restrained by the reaction of a coil spring (not shown). When the speed of the airflow 15 increases to a level at which furling is required, the retaining force of

the spring in the hinge 70 is overcome and the fin 53 will rotate. This causes an out of balance aerodynamic loading on the rotor. This out of balance force will again cause the nacelle to rotate about its mounting axis 42, until the aerodynamic forces on the turbine are in equilibrium. The non-linear furling mechanism 50 according to the present invention will keep the turbine windward and stable until the wind velocity compromises the systems safety and the turbine is progressively yawed from the wind. The furling device 50 therefore reduces constant yawing of the turbine during gusts, which would otherwise create unwanted oscillations and turbine blade noise.

The actual furling angle necessary to protect the wind turbine can be limited because of the presence of the aerofoil 21. A certain furling of the rotor 20 will result in aerodynamic stalling along the foil 21. As soon as the stalling starts, the power of the wind flow 15 on the rotor 20 will drop.

In Fig 6 a schematic overview of a wind turbine heating system is shown. The wind turbine heating system comprises a first water reservoir 118. In the water reservoir one or more electric heating elements 114 are provided. The electrical heating elements 114 are coupled with the wind turbine 10 via a control unit 116. The electrical current generated by the wind turbine 10 will be directed to the electrical heating elements 114 in order to heat up the water contained in reservoir 118. While the

efficiency of the heat transfer for electric heating elements may be considered to be near 100%, operating an element at a lower power input than that for which it was designed results in a lower element temperature. The nature of wind power is such that the power output will usually be considerbly below the overall rated power of the heating system. As such, it is necessary to use heating elements 114 with an appropriate power rating.

The water reservoir 118 is designed to store warm water, prior to use. The reservoir 118 may be a cylinder manufactured from copper alloy, though enamelled steels and plastic may also be used. Steel cylinders are better suited to higher pressure applications, while copper is attractive due to its inherent corrosion resistence and the associated long service-life. For vented systems and their associated lower cylinder pressure, copper cylinders are well suited.

When, using the system according to Fig 6, all of the water in the reservoir 118 has been heated to the maximum allowable temperature, the control unit 116 will no longer allow the heating elements 114 to dissipate power into the water reservoir 118. That means that the power generated by the wind turbine has to be "dumped" elsewhere. As long as the wind turbine 10 is generating electricity, it is essential that there is a means of dissipating the electrical energy at all times.

This is done by using a heating element 115 immersed in water. This can be installed to preheat the water in a cold water reservoir 120. If the volume of the cold water cistern is in the region of 200-300 litres, as is typical of a small house, then this would be sufficient to dissipate any quantity of excess power. If the reservoir 120 were not insulated then much of the heat energy would be lost to the surroundings in any case. The frequency with which the dump load would be utilised should be sufficiently small that there would be no economically feasible means of utilising the excess power. Excess power from the wind turbine could also be directed to a building space-heating system, or used to pre-heat a cold water feed to a boiler or similar water heating equipment.

Water heated in a hot water reservoir 118 with elements 114 will tend to form stratified layers. The temperature within each layer will not vary much as heat will be spread by conduction and convection. A high temperature gradient exists between layers. Heat transfer by conduction is very low in water. This phenomenon would be useful in a situation where several heating elements are used, as the top layer could be heated up, and then left undisturbed by the convection below it as lower layers were subsequently heated.

It should be noted that the heating element design described herein could be used with or without a mains connection in tandem. The mains connection

would allow the immersion heating element (or a dedicated mains element) to provide energy when none is available from the wind turbine.

Typically the rated power of the heating system according to Fig 6 could be in the range of about 3 kW.

With respect to the efficiency of the wind turbine, the power extracted from the wind by the rotor should be limited to approximately 60% (59,6%). Because of the fact that the wind turbine according to the present invention will be operated in mainly turbulant airflows, the efficiency of the wind turbine according to the present invention can be improved by adding a new control system.

Fig 7 schematically shows the working of the control system according to the present invention. First, the load on the wind turbine is near a predetermined starting level (L0). The control system will measure the corresponding yields of the wind turbine. Thereafter the load on the wind turbine is increased or decreased by a small amount. In the example of Fig 7 the load on the wind turbine is decreased. Thereafter the control system measures the new yield level of the wind turbine. If the yield is found, the same procedure is repeated. That means that as long as the yield increases the load will be decreased. As soon as a further decrease of the load will result in a decrease of the yield, the process is reversed. That means that

then the load on the wind turbine will be increased and the corresponding effect on the yield will be monitored.

Because of the fact that the wind velocity on the rotor will be continuously alternating, the time interval for increasing and decreasing the amount of load on the wind turbine will typically be in the range of several microseconds.

The efficiency of the wind turbine heating system can be further increased when using an alternative water reservoir 120 as shown in Fig 8. The water reservoir 119 is provided with an electrical heating element 124. The heating element 124 is covered, over a substantive length thereof, by means of an enclosing tube 125. The bottom end 126 of the tube 125 is open. This enables water to flow in between the exterior of the heating device 124 and the interior of the tube 125. As soon as current passes through the element 124 the electrical energy will be converted into heat energy and this heat energy is then transferred to the water. The water film directly enclosing the heating element 124 will be heated and, due to natural convection, will flow towards the top of the reservoir 128 and is prevented from diffusing radially into the reservoir 128. Because of the presence of the tube 125 the heated water is directed towards a warm water zone 130 in a top part of the reservoir 128. The heat generated by the heating element 124 therefore is concentrated in the top part of the reservoir 128

and is prevented from diffusing radially into the reservoir 128. This will limit the time necessary to heat up water to a preferred temperature thus reducing the energy consumption of thereof.

As soon as the power generated by the wind turbine is increased, the amount of heat transferred to the water in the reservoir 128 is also increased. This means that the flow of heated water towards the top part of the reservoir 128 will increase, resulting in mixing the thermally stratified layers, and in an enlarged warm water area 130. This effect is shown in Fig 9. Because of the construction of the reservoir 128, power no longer has to be "dumped". The use of the reservoir 128 is especially suitable for a wind turbine, because of the fact that the nature of wind power is such that the power output will usually fluctuate and moreover will be below the overall rated power of the heating system.

During normal operation of a wind turbine according to the invention, vibrations are caused by harmonic resonance within the turbine, tower and mounting structure. These come from blade imbalances, due to deformation during operation or bearing vibration in the generator and turbine hub. Eliminating resonance in micro-wind turbines is especially difficult as they operate through a wide range of turbine tip-speeds. The design described below reduces the operating vibrations by controlling the turbine tip-speeds so that they

remain outside natural resonant frequencies, and through novel vibration absorption measures. Mounting a horizontal axis wind turbine on a building structure requires the damping of critical frequencies and the moving of harmonics beyond the system operating frequencies. The damping system on the rooftop wind turbine is integrated into the design of the mounting means and nacelle of the turbine. These vibration absorbing systems work together to create a silent running rooftop turbine.

The novel wind turbine mounting bracket uses a sandwich construction of viscoelastic materials and structural materials.

The mounting means tower contains an innovative core, typically of rubber, which has some sections which have a reduced cross-sectional area and are not in contact with the mounting means' inner surface and some sections which are. This serves to absorb vibrations in the mounting means through the energy dissipated in the rubber core before they reach the mounting bracket. The rubber core also acts to force the system's resonant frequency above the turbine driving frequency.

In Fig 10 a possible embodiment of the interior of the mounting means is shown, in cross-section. In this embodiment, the mounting means is tubular in cross-section. The mounting means 40 comprises a hollow core wherein a cylindrical core element 90 is present. The core element 90 in the middle thereof

is provided with a hollow section 91 in order to allow elements such as a power line to be guided through the interior of the core element 90. The core element 90 is provided with sections 92 with an exterior diameter corresponding substantially to the interior diameter of the mounting means 40. These sections alternate with sections 93 that have a reduced diameter and are not in contact with the mounting means' 40 inner radial surface. The sandwich mounting bracket together with the mounting means core design suppresses vibrations in the system. The main sources for those vibrations are vibrations transmitted from the wind turbine to the building, and the aerodynamic turbulence around obstacles, which decreases power output but more importantly shortens the working life of the wind turbine.

In Fig.11 an alternative embodiment of the interior of the mounting means is shown, in cross-section. The hollow core of the mounting means 40 is provided with a core element 94. The core element 94 in the middle thereof is provided with a hollow section 91. The core element 94 is provided with sections 92 with an exterior diameter corresponding substantially to the interior diameter of the mounting means 40. These sections alternate with sections 93 that have a reduced diameter and are not in contact with the mounting means' 40 inner radial surface. When comparing Figs 10 and 11 it will be clear that the shape of the recesses in respective core elements 90 and 94 differs. It should be noted

that Figs 10 and 11 are for illustration purposes only. Alternative embodiments for the core elements are also possible.

Fig 12 shows a further embodiment of the interior of the mounting means 40. As shown in Fig 12, the interior of the mounting means 40 comprises several core elements 95, which are inserted in the mounting means wherein a first element 95 abuts an adjacent element 95. In the example of Fig 12 the shape of the recesses in the respective elements 95 again differs from the embodiments according to Fig 10 and Fig 11.

In a wind turbine noise comes from two areas, aerodynamic sources and mechanical sources. Aerodynamic noise is radiated from the blades, originating due to the interaction of the blade surfaces with turbulence and natural atmospheric or viscous flow in the boundary layer around the blades. Mechanical noise is due to the relative motion of mechanical components and the dynamic response among them. This effect may be magnified if the nacelle, rotor and tower transmit the mechanical noise and radiate it, acting as a loudspeaker. Two types of noise problem exist: air borne noise which is noise which is transmitted directly from the component surface or interior into the air, and structure borne noise which is transmitted through the structure before being radiated by another component.

The turbine mounting and mounting means are designed to push the resonant frequency of the whole structure above the operation vibration frequencies caused by blade unbalances and deformations. The mounting contains a damping system which eliminates vibrations.

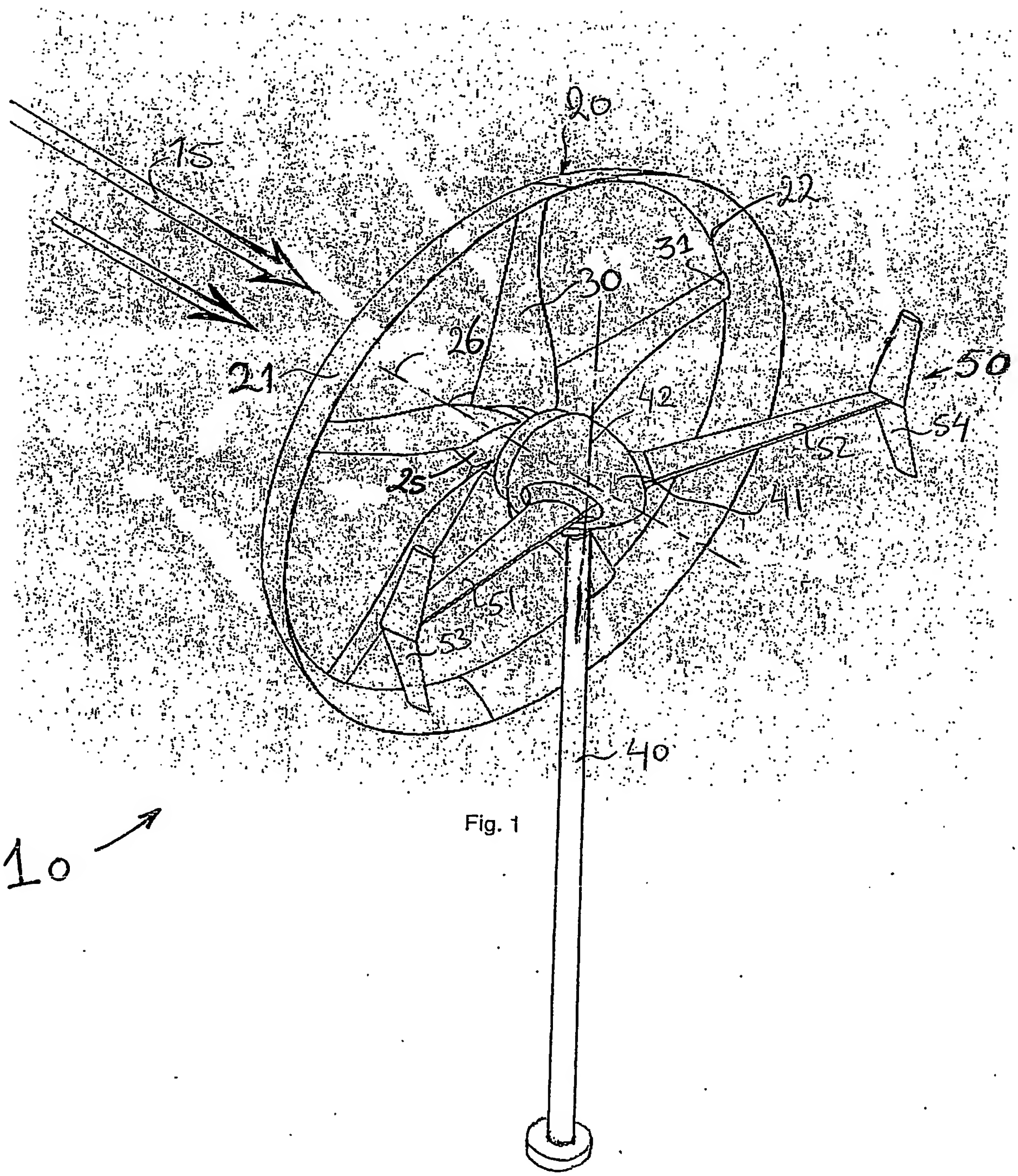


Fig. 1

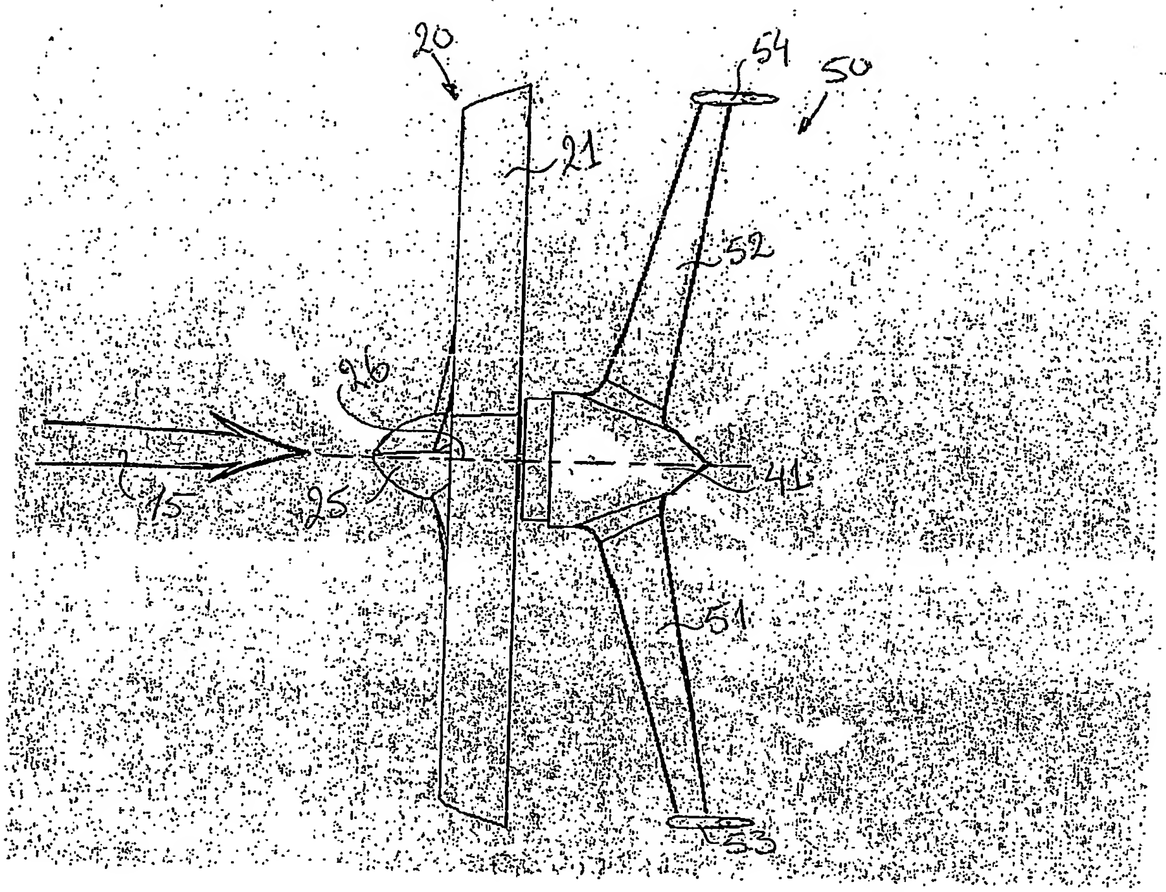


FIG. 2

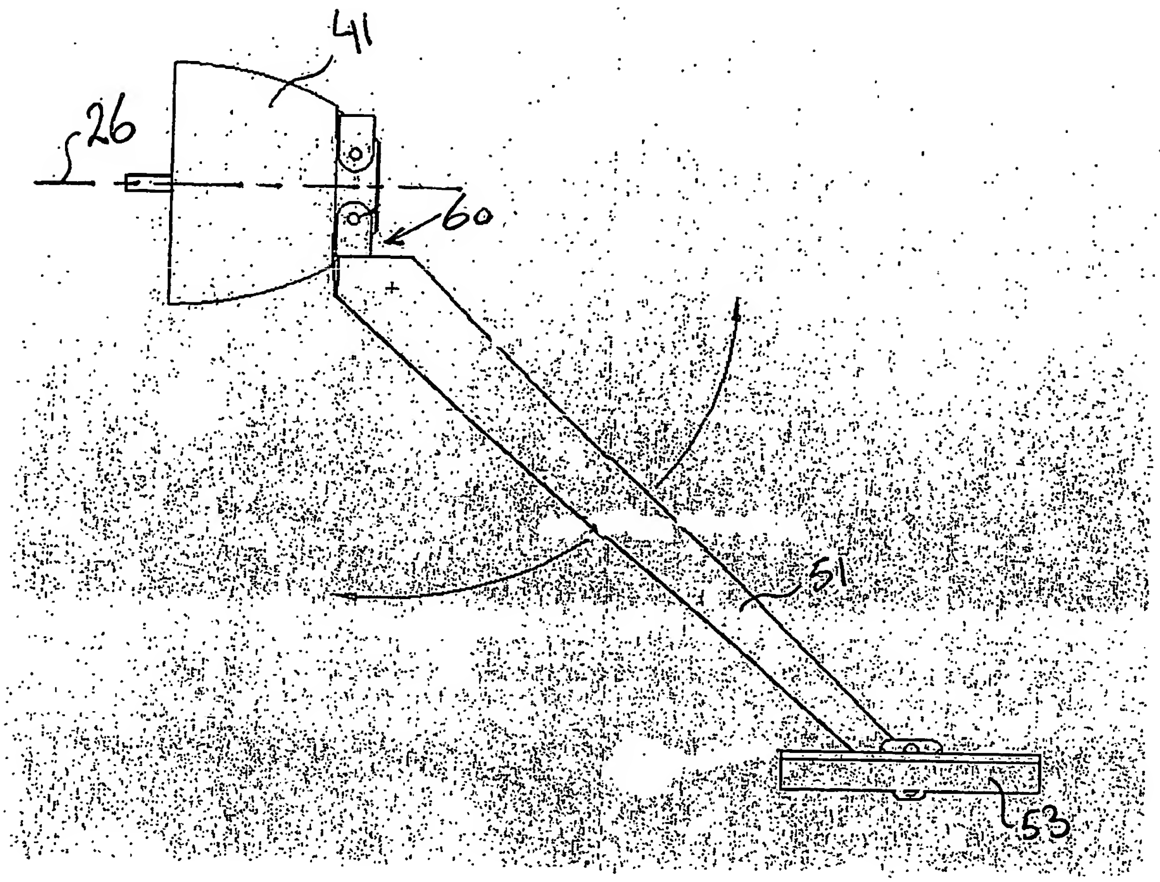


Fig. 3

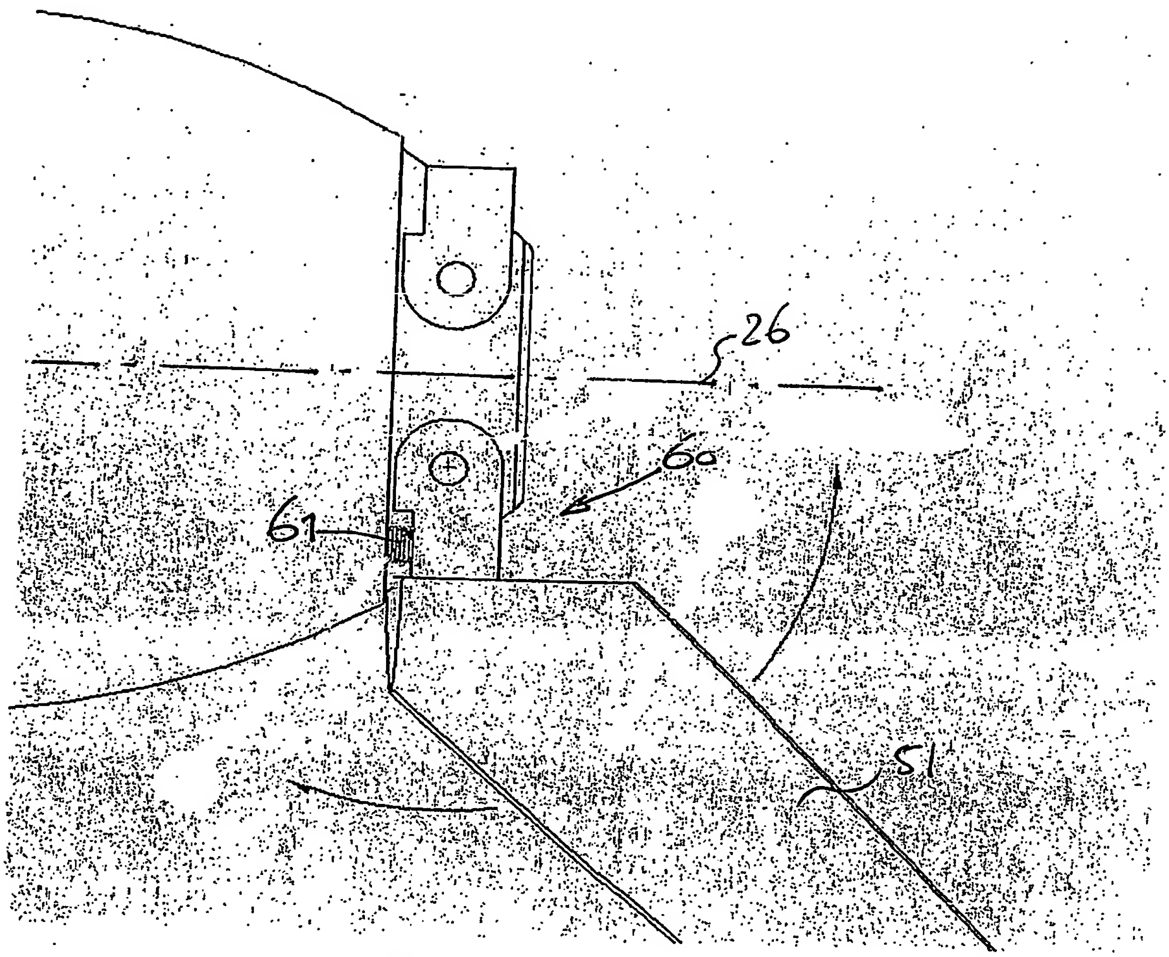


FIG. 4

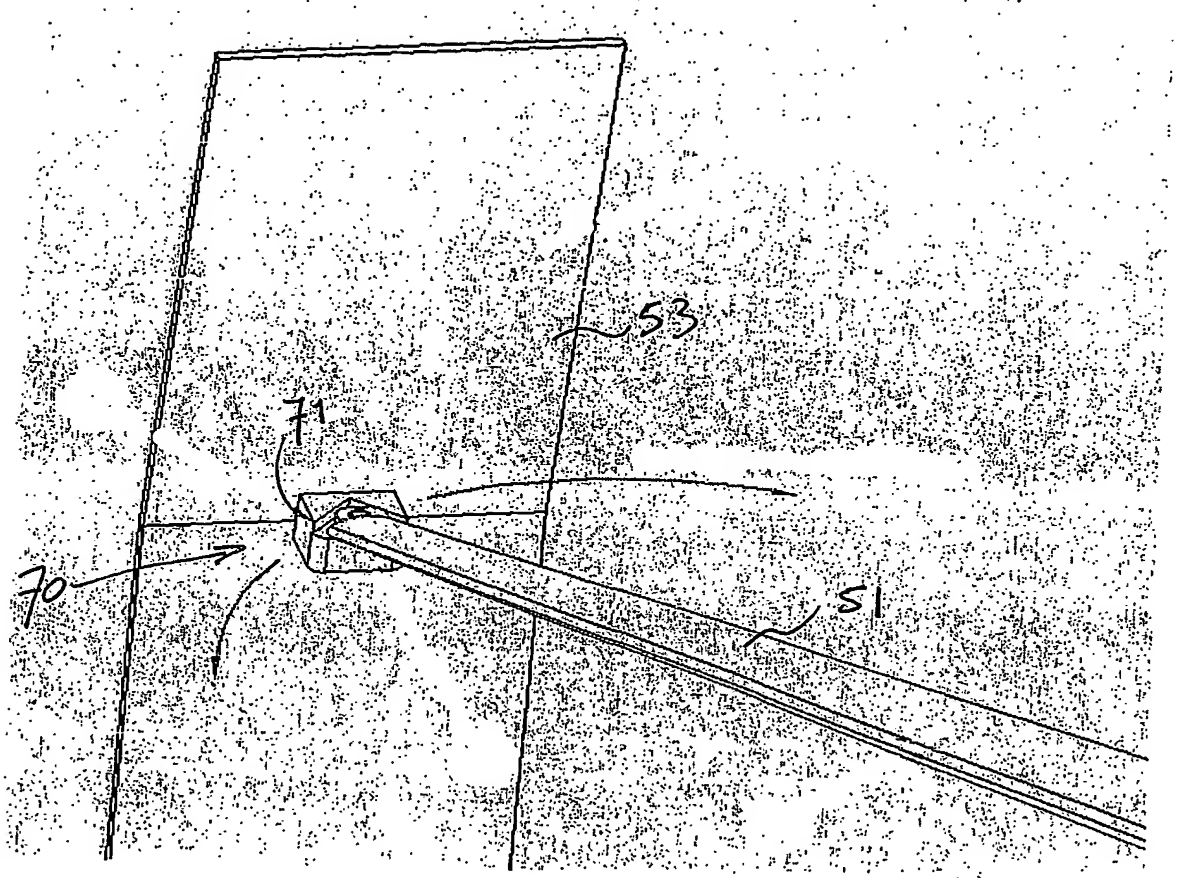


FiG. 5

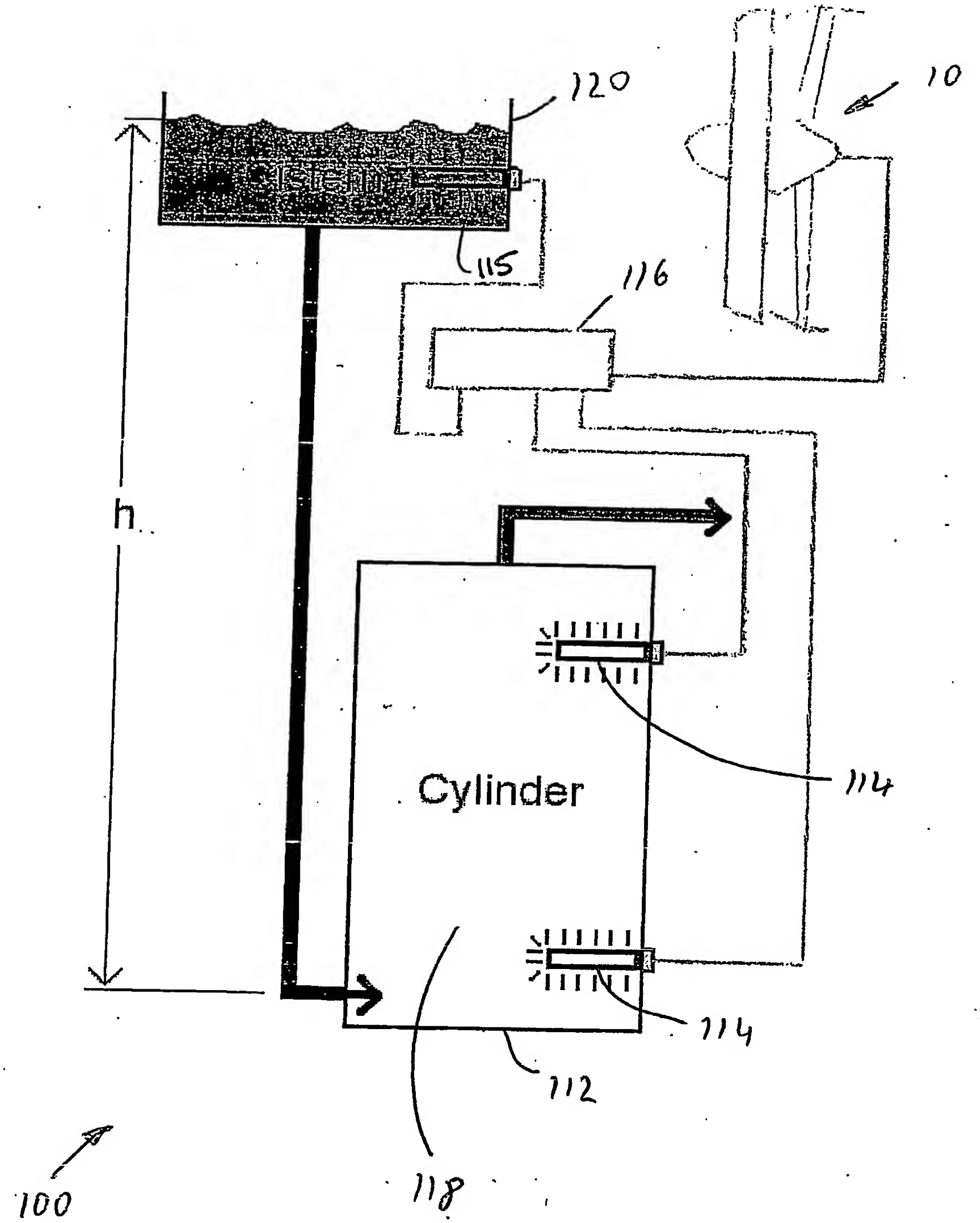


FiG.6

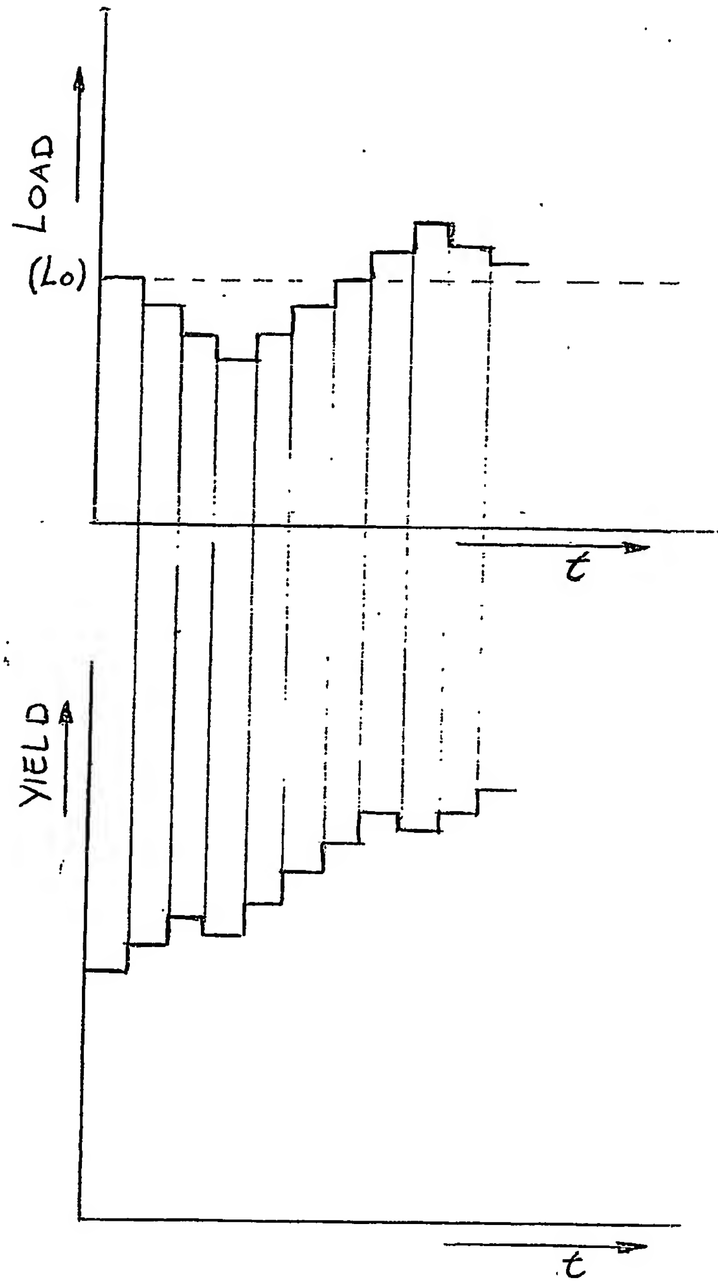


FIG. 7

FIG. 8

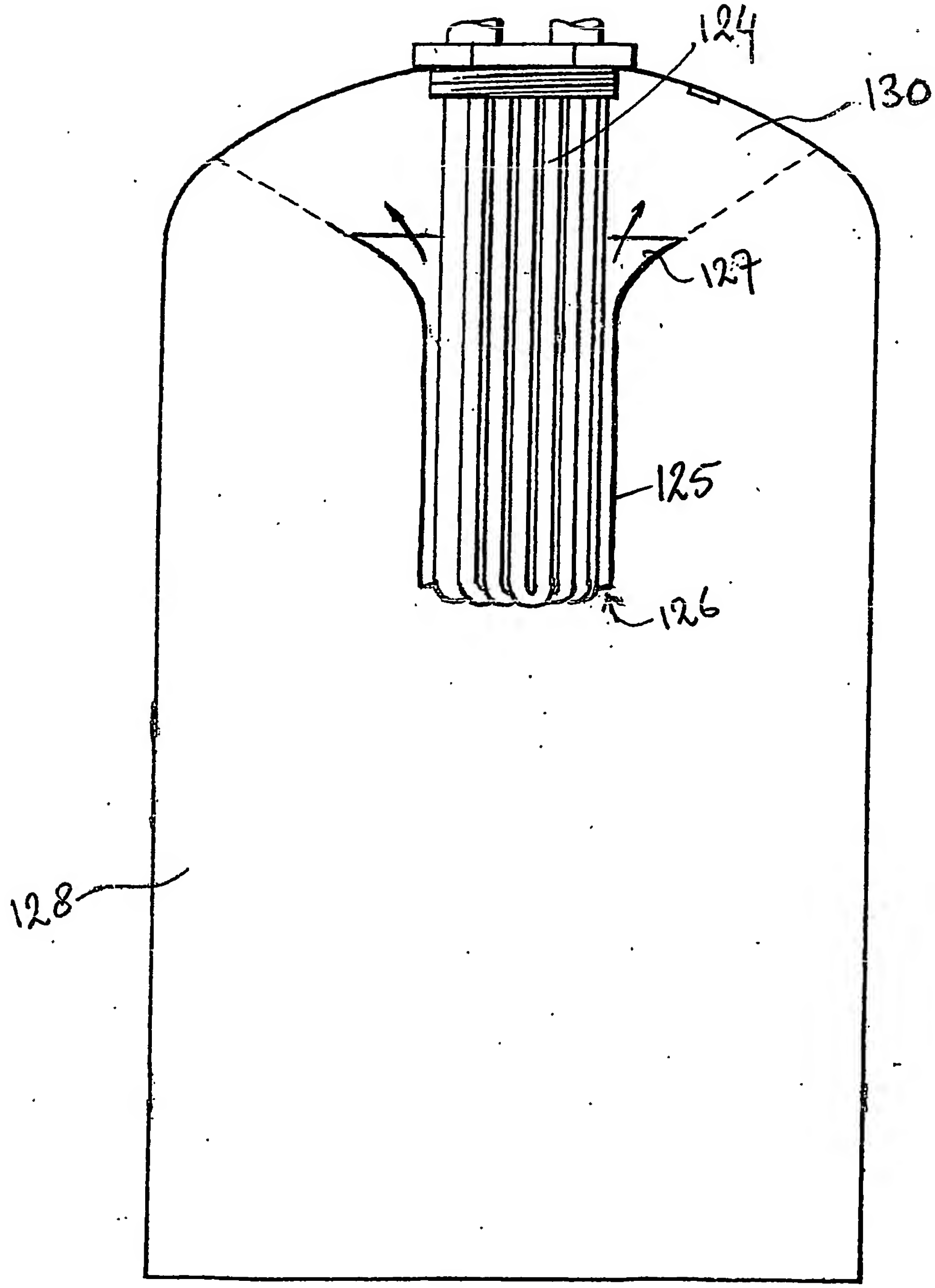
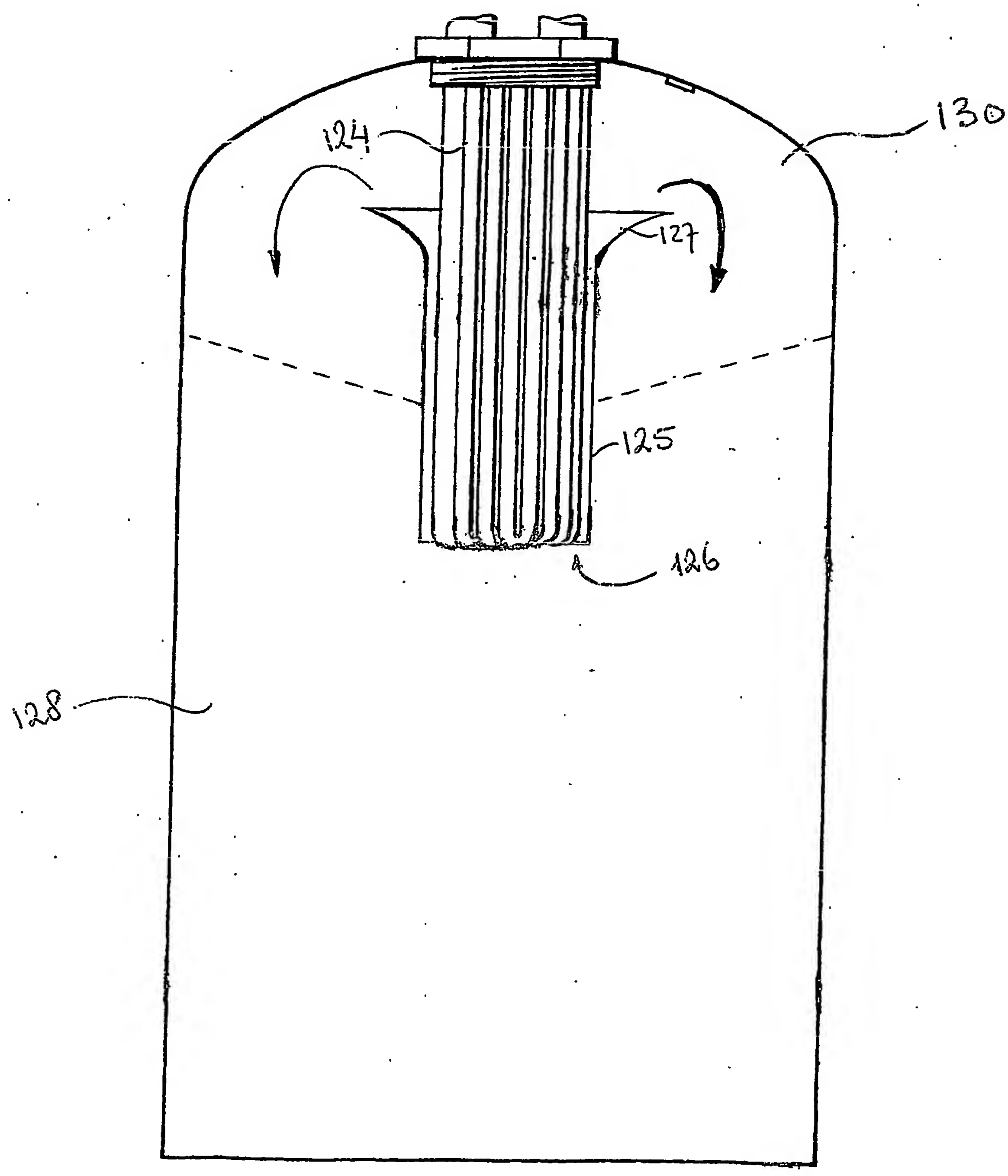


FIG. 9



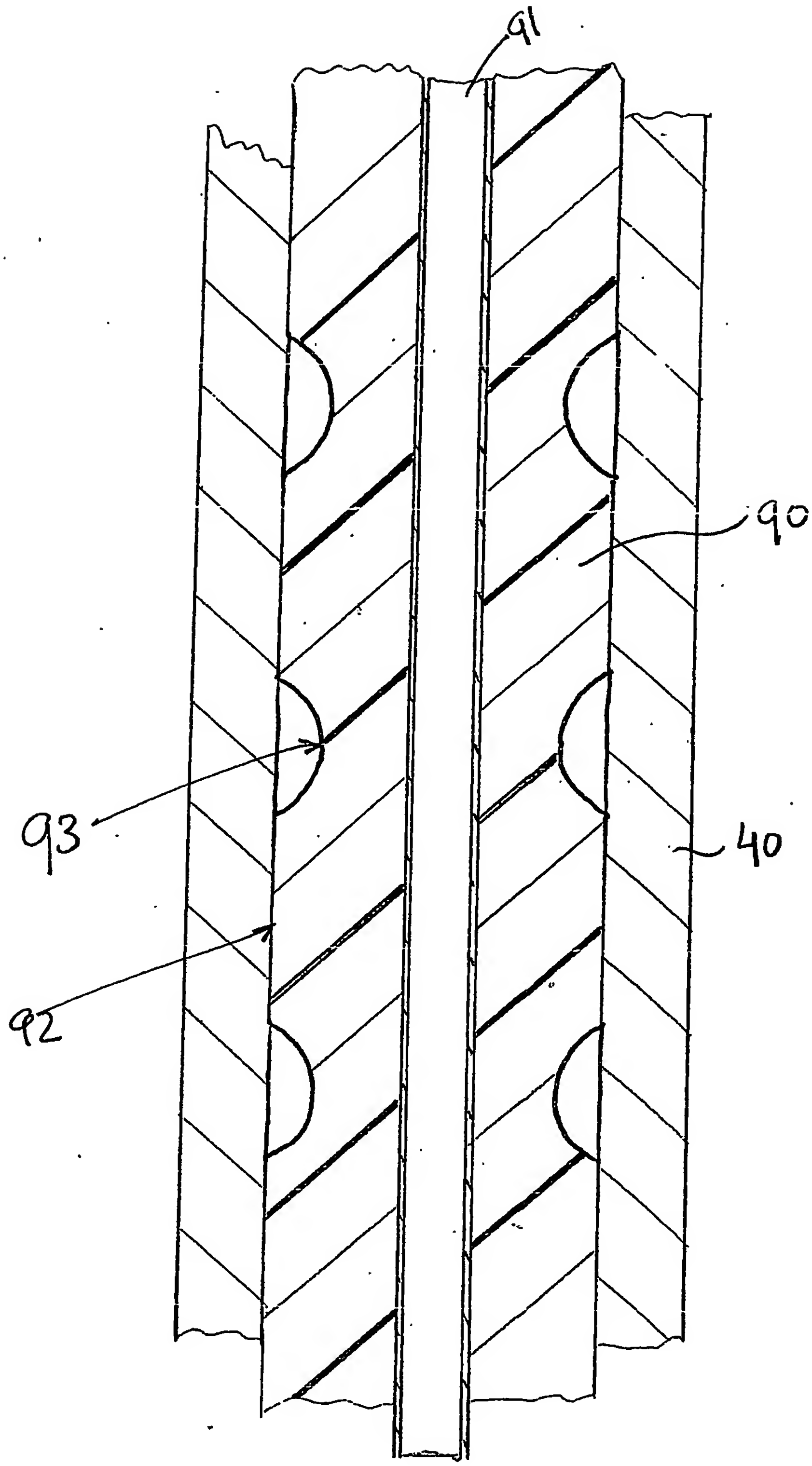


Fig. 10

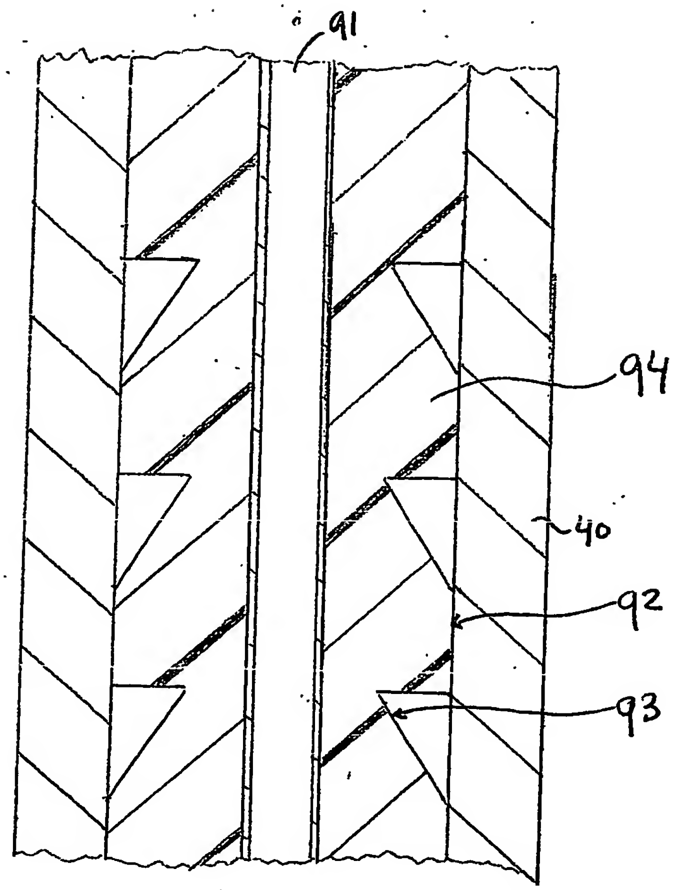


FIG. 11

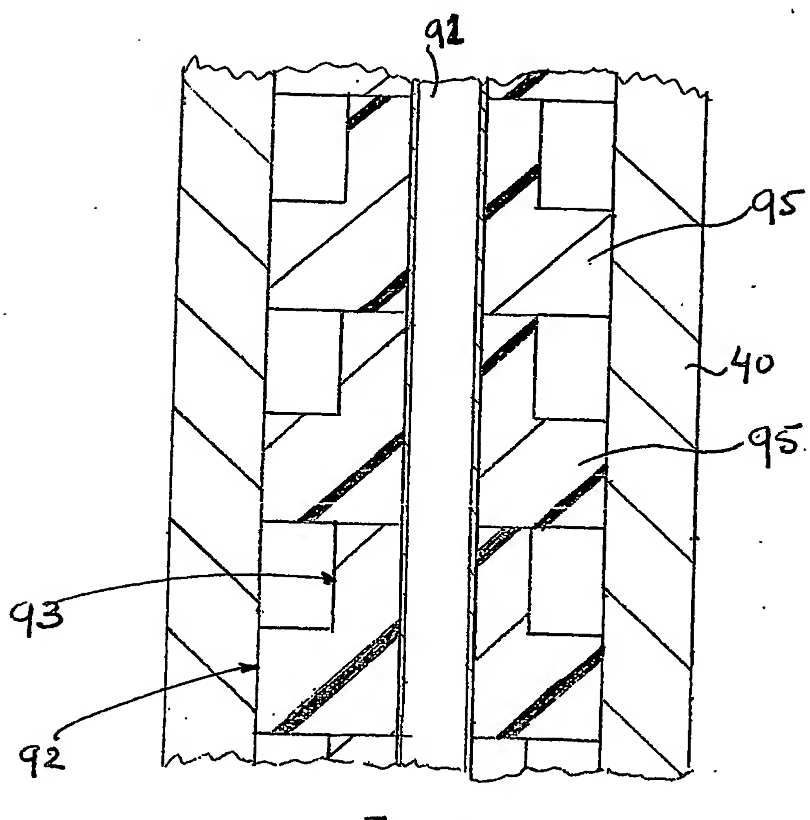


FIG. 12

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